# 04271 Abstracts Collection
# Preferences: Specification, Inference, Applications
## — Dagstuhl Seminar —

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**Abstract.** From 27.06.04 to 02.07.04, the Dagstuhl Seminar 04271 "Preferences: Specification, Inference, Applications" was held in the International Conference and Research Center (IBFI), Schloss Dagstuhl. During the seminar, several participants presented their current research, and ongoing work and open problems were discussed. Abstracts of the presentations given during the seminar as well as abstracts of seminar results and ideas are put together in this paper. The first section describes the seminar topics and goals in general. Links to extended abstracts or full papers are provided, if available.

**Keywords.** Preference specification and representation, preference composition and merging, preference aggregation, axiomatic properties of preferences, logics of preference, topological/algebraic preference structures and their utility representation, linear and non-linear utility representations, preferences with intransitive indifference

## 04271 Summary – Preferences: Specification, Inference, Applications

"Preference" is a fundamental notion in those areas of computer science, applied mathematics and philosophy that deal with decisions and choice. In Mathematical Decision Theory, preferences (often expressed as utilities) are used to model people's economic behavior. In Artificial Intelligence, preferences help to capture agents' goals. In Databases, preferences help in reducing the amount of information returned in response to user queries. In Philosophy, preferences are used to reason about values, desires, and duties. Surprisingly, there has been so far very little interaction between those areas. The difference in foci, as well as variations in terminology, make the results obtained in one area difficult to use in another.

This Dagstuhl seminar gathered researchers from many areas involving preferences (in particular databases, AI, mathematics, decision science, philosophy) in order to stimulate more specialized research in those areas and identify possible directions for collaboration. The following topics where covered during the seminar week.

*Topics:*

* Preference specification and representation
* Preference composition and merging
* Preference aggregation
* Axiomatic properties of preferences
* Logics of preference
* Topological/algebraic preference structures and their utility representation
* Linear and non-linear utility representations
* Preferences with intransitive indifference
* Preference elicitation and learning
* Preference revision
* Incomplete or inconsistent preferences
* Reasoning about preferences
* Priorities in reasoning, conflict resolution and belief revision
* Preference query languages
* Preference query evaluation and optimization
* Preference mining
* Preference repositories
* Preference-driven search engines
* Preference-driven human-computer interaction
* Recommendation systems and other e-commerce applications
* Constraints and preferences, "soft" constraints
* Preference logic programming
* Preference and choice
* Alternatives to preferences

This seminar was unanimously rated as very successful by all participants at the end of a wonderful stay in Dagstuhl. As a main result it was agreed to organize a successor event in the same multi-disciplinary mode. This follow-up event was held as "IJCAI-05 Multi-Disciplinary Workshop on Advances in Preference Handling" in conjunction with the International Conference on Artificial Intelligence IJCAI, July 31 - Aug. 1, 2005, in Edinburgh, Scotland. For 2006 it is planned to continue this tradition as "ECAI-06 Multi-Disciplinary Workshop on Advances in Preference Handling", in conjunction with the European Conference on Artificial Intelligence ECAI in Riva del Garda, Italy, Aug. 28-29.

## 04271 Seminar Program – Preferences: Specification, Inference, Applications

*Monday, 28.06.04*

9:00 – 9:05 Introduction/Welcome
9:05 – 9:35 E. Indurain Invitation to Topological Social Choice
9:35 – 10:35 W. Kießling Preference Modeling and Preference Query Languages
10:35 – 11:00 Coffee break
11:00 – 12:00 S. Holland Gaining Valuable Customer Knowledge with Data Mining and Preference Mining
12:15 – 14:00 Lunch
14:00 – 14:45 C. Domshlak Graphical Models of Preferences
14:45 – 15:30 F. Rossi Soft Constraints
15:30 – 16:00 Coffee break
16:00 – 17:00 J. Chomicki Optimization of Preference Queries
17:00 – 18:00 W. T. Balke Efficient Evaluation of Numerical Preferences: Top k Queries, Skylines and Multi-objective Retrieval

*Tuesday, 29.06.04*

*Chair: G. Bosi*
9:00 – 9:30 P. La Mura Introduction to Utility Theory
9:30 – 10:00 M. Pirlot Axiomatic Approach to Concordance Relations in Conjoint Measurement Perspective
10:00 – 10:30 A. Tsoukias Preferences on Intervals
10:30 – 11:00 Coffee break

*Chair: G. Brewka*
11:00 – 11:30 R. Brafman Constraint Optimization with CP-Nets and Its Applications to Adaptive Multi-Media Presentations
11:30 – 12:00 N. Wilson A Logic of Conditional Preferences
12:15 – 13:45 Lunch
13:45 – 14:00 Presentation of Participants

*Chair: C. Domshlak*
14:00 – 14:30 G. Brewka Answer Set Optimization
14:30 – 15:00 T. Schaub Preferences in Answer Set Programming
15:00 – 15:30 P. Dell'Acqua Preference Reasoning in Logic Programming
15:30 – 16:00 Coffee break

*Chair: W. Kießling*
16:00 – 16:30 P. Pu User-Involved Preference Elicitation for Online Product Catalogs
16:30 – 17:00 J. Goldsmith POET, the Programmable Online Elicitation Tool
17:00 – 17:30 P. La Mura Non-parametric Estimation of Consumer Preferences
17:30 – 18:00 E. André A Perceptual Interface for Inferring the User's Music Preferences

*Wednesday, 30.06.04*

*Chair: T. Schaub*
9:00 – 9:30 K. Mainzer Preferences and Bounded Rationality: Decisions in a Complex World
9:30 – 10:00 E. Weydert Defaults and Preferences – on Mutual Enlightment
10:00 – 10:30 A. Mileo Preferences in Declarative Policy Description and Enforcement in Network Context
10:30 – 11:00 Coffee break

*Chair: W. T. Balke*
11:00 – 11:30 P. Ciaccia Evaluating Queries with non-Transitive Preferences
11:30 – 12:00 G. Koutrika Personalization of Database Queries Using Stored Preferences
12:15 – 13:00 Lunch
13:00 – 20:00 Excursion

*Thursday, 01.07.04*

*Chair: E. Indurain*
9:00 – 9:30 M. Campion Ordinal Representability in Banach Spaces
9:30 – 10:00 G. Bosi Nonlinear Utility Functions for Nontotal and Nontransitive Binary Relations
10:00 – 10:30 G. Herden On the Continuous Analogue of the Szpilrajn Theorem
10:30 – 11:00 Coffee break

*Chair: T. Walsh*
11:00 – 11:30 J. Lang Preference Representation and Social Choice
11:30 – 12:00 F. Rossi Voting Theory for Preference Aggregation
12:15 – 14:00 Lunch
Chair: F. Rossi
14:00 – 14:30 U. Junker Preference-based Problem Solving for Constraint Programming
14:30 – 15:00 N. Wilson A Logic of Conditional Preferences
15:00 – 15:30 C. Domshlak Quantitative Reasoning with Qualitative Preferences
15:30 – 16:00 Coffee break

*Chair: U. Junker*
16:00 – 16:30 B. Venable Temporal Preferences
16:30 – 17:00 D. v. Nieuwenborgh An Ordered Logic Program Solver
17:00 – 17:30 S. Kaci Representing Preferences in the Possibilistic Framework
17:30 – 18:00 S. Fuchs-Seliger Non-transitive Consumer Behavior

## Efficient Evaluation of Numerical Preferences: Top k Queries, Skylines and Multi-objective Retrieval

*Wolf-Tilo Balke (L3S Research Center and Hanover University, D)*

Query processing in databases and information systems has developed beyond mere SQL-style exact matching of attribute values. Scoring database objects according to numerical user preferences and retrieving only the top k matches or Pareto-optimal result sets (skyline queries) are already common for a variety of applications.

Recently a lot of database literature has focussed on how to efficiently evaluate queries based on numerical preferences. Specialized algorithms using either top k retrieval (assuming a single compensation function defined over all query predicates, i.e. a global utility function) or computing skylines (assuming all query predicates as pairwise incomparable) have been shown to be capable of avoiding naïve linear database scans by pruning large numbers of database objects and thus vastly improve scalability. However, both paradigms are only two extreme cases of exploring viable compromises for each user's objectives, which may or may not be comparable. To find the correct result set for arbitrary cases of multi-objective query processing in databases a novel algorithm for computing sets of objects that are non-dominated with respect to a set of monotonic objective functions representing a user's notion of utility, has recently been presented. Naturally containing top k and skyline retrieval paradigms as special cases, this algorithm maintains scalability also for all cases in between. To be more precise, in both special cases the multi-objective retrieval algorithm will behave exactly like the most efficient known evaluation algorithms for top k and skyline queries respectively. This algorithm has also been proved to be correct and instance-optimal in terms of necessary object accesses. Moreover, it improves the psychological response behavior by progressively producing result objects as quickly as possible, while the algorithm is still running, so user can deal with result objects at the earliest point in time.

Our tutorial will discuss all state of the art algorithms for top k retrieval, skyline queries and multi-objective retrieval and point to open problems, future extensions of the paradigm and research in numerical preferences.

*Keywords:* Top k retrieval , skyline queries, multi-objective optimization, numerical preferences, utility functions

## Constrained Optimization with CP-Nets and Its Application to Adaptive Multi-Media Presentations

*Ronen I. Brafman (Ben Gurion University, IL)*

In this talk I will discuss the problem of constrained optimization in the context of qualitative preferences orders defined via TCP-nets, discuss some algorithms for its solution and run a demo of a system for adaptive multi-media content display based on this technology.

## Adaptive Rich Media Presentations via Preference-Based Constrained Optimization

*Ronen I. Brafman (Ben Gurion University, IL)*

Personalization and adaptation of multi-media messages are well known and well studied problems. Ideally, each message should reflect its recipient's interests, device capabilities, and network conditions. Such personalization is more difficult to carry out given a compound multi-media presentation containing multiple spatially and temporally related elements. This paper describes a novel formal, yet practical approach, and an implemented system prototype for authoring and adapting compound multi-media presentations. Our approach builds on recent advances in preference specification and preferences-based constrained optimization techniques.

*Keywords:* Preferences, cp-nets, multi-media presentations

*Joint work of:* Brafman, Ronen I.; Friedman, Doron

*Full Paper:* http://drops.dagstuhl.de/opus/volltexte/2006/405

## Ordinal representability in Banach spaces.

*Maria Jesus Campion (Public University of Navarra, E)*

The objective is to investigate the role of ordinal representability in the theory of Banach spaces. Necessary and sufficient conditions have been achieved for the norm or weak topologies of a Banach space to have the continuous (respectively, semicontinuous) representability property.

*Keywords:* Banach spaces, weak topologies,total preorders, continuous and semicontinuous isotonies

*Joint work of:* Campion, Maria Jesús; Candeal, Juan Carlos; Granero, Antonio S.; Induráin, Esteban

## Evaluating Queries with non-Transitive Preferences

*Paolo Ciaccia (Università di Bologna, I)*

Current approaches to the mananagement of preference queries over large databases assume that the preference relation is (at least) a partial order. In this talk I'll present some recent original work that shows how, using a "filter & refine" approach, it is possible to answer queries even in the case of arbitrary, in particular non-transitive, preferences without resorting to the trivial nested-loops algorithm.

*Keywords:* Preference queries

## Ordering vs. Filtering in Evaluating Database Preference Queries

*Carmel Domshlak (Technion - Haifa, IL)*

In this talk we consider the challenge of preference elicitation in systems that help users discover the most desirable item(s) within a given database. In recent years, the database community has paid increasing attention to the formulation and treatment of preference queries. In this talk we discuss a number of semantic and computational issues that preference queries raise.

First, we examine the currently favored interpretation of such queries in the DB literature, showing that it is very problematic semantically. As an appealing alternative we suggest the "ceteris paribus" semantics that has long been accepted by economists and philosophers. We examine the computational problem of evaluating preference queries using the recently introduced operator BEST. We show that while BEST can be intractable given the ceteris paribus semantics, an appealing alternative, ORD, can be implemented efficiently for a wide class of preference queries.

Next, we overview a novel methodology for elicitation and reasoning about preference queries, based on a "user-friendly" obtaining of a user value function for the purpose of sorting a (structured) database or identifying the most desirable item(s) in it. The core of this methodology is a preference elicitation technique based on TCP-nets and pair-wise comparisons between some items in the database. In large, the methodology is based on a hybrid qualitative/quantitative framework, where the user incrementally provides us with some qualitative statements about her preferences, while the system is working with a value function automatically generated from the given qualitative information. On the technical side, the methodology is based on a set of strong representation theorems for factored value functions.

*Joint work of:* Domschlak, Carmel; Brafman, Ronen I.

## Non-Transitive Consumer Behavior

*Susanne Fuchs-Seliger (Universität Karlsruhe, D)*

Rational choice when preferences are not required to be transitive and complete has been discussed in the literature for years. In this article transitivity and completeness of the preference relation is also not assumed. It will be shown that nevertheless the existence of a competitive equilibrium can be proven when those properties are replaced by a domination property which allows that there could be cicles among those alternatives which are of less importance for the individual and which he or she would never choose if better ones are available.

Moreover, one can show that the compensated demand function is continuous under very weak conditions, and because of this, Shephard's lemma follows without assuming transitivity and completeness of the underlying preferences.

*Keywords:* Rational choice, consumer behavior, competitive equilibrium

*Full Paper:* http://drops.dagstuhl.de/opus/volltexte/2006/402

## On the continuous analogue of the Szpilrajn-Marczewski Theorem

*Gerhard Herden (Universität Duisburg-Essen, D)*

One of the most quoted and generalized theorems in many fields of pure and applied mathematics as, for instance, order theory, mathematical logic, computer sciences, mathematical social sciences, mathematical economics, computability theory and fuzzy mathematics is the Szpilrajn-Marczewski Theorem which states that every partial order can be refined or extended to a total (linear) order. Since in mathematical social sciences or, more general, in any theory that combines the concepts of topology and order one is mainly interested in continuous total orders or preorders in this paper the continuous analogue of the Szpilrajn-Marczewski Theorem is discussed. It will be shown that the continuous analogue of the Szpilrajn-Marczewski Theorem does not hold in general. In addition, necessary and in some (interesting) cases also necessary and sufficient conditions for a topological space to satisfy the continuous analogue of the Szpilrajn-Marczewski Theorem will be presented.

*Keywords:* Continuous binary relation, (weakly) continuous binary relation, Szpilrajn-Marczewski property, chain, connected topology

## Gaining Valuable Customer Knowledge with Data Mining and Preference Mining

*Stefan Holland (Universität Augsburg, D)*

Advanced personalized e-applications require comprehensive knowledge about their user's likes and dislikes in order to provide individual product recommendations, personal customer advice and customer-tailored product offers. We model such preferences as strict partial orders with "A is better than B" semantics. In this talk preference mining techniques for the detection of strict partial order preferences in user log data were presented. The main advantage of our approach is the semantic expressiveness of the preference mining results. With our approach personalized e-applications can gain valuable knowledge about their customer's preferences, which is essential for a qualified customer service.

## Invitation to Topological Social Choice

*Esteban Indurain (Public University of Navarra, E)*

An important part of Mathematical Social Choice tries to aggregate the individual preferences of a finite set of agents into a "social" preference that somewhat reflects the main features of the individual preferences, accomplishing some common sense restrictions as the respect of unanimity (i.e. . if all the individuals have defined the same preference, the social preference must also coincide with suich identical individual preferences), or the anonymity among others.

However, as a matter of fact the most common feature in this context is to get an "impossibility result" that says that under some list of "common sense restrictions" there is no possible social preference satisfying all the restrictions imposed. This happens in the well known "Arrow's impossibility theorem, issued in 1951 and in several other results in the Literature, issued since then, and dealing mainly on combinatorial methods.

However, when the space of preferences has some topological structure, under a milder set of common sense restrictions, as continuity, respect of unanimity, and respect of anonymity, some possibility results are still possible, but depending, strongly, of the topological structure of the space. For example, for finite cellular spaces, the existence of a rule that allows us to aggregate preferences for any finite number of agents, is equivalent to the topological contractibility of the space. This kind of new methods were intruduced in the last 1970's by Chichilnisky and Heal among others. we shall present here a panorama of these new topological methods and their main results achieved.

*Keywords:* Individual preferences, social preferences, aggregation of preferences, topological methods in social Choice

## Preference-based Problem Solving for Constraint Programming

*Ulrich Junker (ILOG - Valbonne, F)*

Combinatorial problems such as scheduling, resource allocation, and configuration have many attributes that can be subject of user preferences. Traditional optimization approaches compile those preferences into a single utility function and use it as the optimization objective when solving the problem, but neither explain why the resulting solution satisfies the original preferences, nor indicate the trade-offs made during problem solving. We argue that the whole problem solving process becomes more transparent and controllable for the user if it is based on the original preferences. We show how the original preferences can be used to control the problem solving process and how they can be used to explain the choice and the optimality of the detected solution. Based on this explanation, the user can refine the preference model, thus gaining full control over the problem solver.

*Keywords:* Multi-criteria optimization, preferences, explanations

*Full Paper:* http://drops.dagstuhl.de/opus/volltexte/2006/399

## Representing preferences in the possibilistic setting

*Souhila Kaci (Université d'Artois - Lens, F)*

The accurate and easy representation of users' preferences in information engineering systems becomes an important issue. Possibility theory provides a generic framework for the qualitative representation of preferences, where several equivalent information formats co- exist (distribution, logical bases, conditionals, graphical networks). Moreover, a bipolar representation distinguishing between positive and negative preferences has been developed in this setting. The paper offers a comprehensive survey of these representation issues.

*Keywords:* possibility, preference, possibilistic logic

*Joint work of:* Kaci, Souhila; Dubois, Didier; Prade, Henri

*Full Paper:* http://drops.dagstuhl.de/opus/volltexte/2006/406

## Preference Modeling and Preference Query Languages

*Werner Kießling (Universität Augsburg, D)*

This extended tutorial covers fundamental aspects of preferences in database systems and personalized database applications. Preferences are modeled as strict partial orders. The specification of preferences follows an intuitive constructor-driven paradigm to facilitate the design and implementation of preference query languages. For preference querying, preferences are interpreted as soft selection constraints under the BMO query model. Several implementations of such BMO query languages, differing in the repertoire of supported preference constructors, exist today; e.g. skylines, various approaches using numerical ranking in combination with the top-k model, Preference SQL and Preference XPath. Then the use of BMO query languages in practical database applications is addressed. In particular, practical experiences are reported for the following application domains: Preference SQL for building personalized query engines for e-commerce, Preference XPath for building a fully automated virtual sales agent for e-procurement (COSIMA) and for building a deeply personalized MPEG-7 based digital multimedia library (P-News). Finally novel research results are reported, augmenting the presented constructor-driven preference model by additional means to express personalized user semantics. It is argued that not only the empty-result effect, but also the infamous flooding effect can be tamed by BMO query languages with such a rich repertoire of preference constructors.

## Personalization of Queries based on User Preferences

*Georgia Koutrika (University of Athens, GR)*

Query Personalization is the process of dynamically enhancing a query with related user preferences stored in a user profile with the aim of providing personalized answers. The underlying idea is that different users may find different things relevant to a search due to different preferences. Essential ingredients of query personalization are: (a) a model for representing and storing preferences in user profiles, and (b) algorithms for the generation of personalized answers using stored preferences. Modeling the plethora of preference types is a challenge. In this paper, we present a preference model that combines expressivity and concision. In addition, we provide algorithms for the selection of preferences related to a query and the progressive generation of personalized results, which are ranked based on user interest.

*Keywords:* Query personalization, user profiles, preferences

*Joint work of:* Koutrika, Georgia; Ioannidis, Yannis

*Full Paper:* http://drops.dagstuhl.de/opus/volltexte/2006/403

## Non-parametric Estimation of Consumer Preferences

*Pierfrancesco La Mura (Handelshochschule Leipzig, D)*

This paper introduces the first non-parametric approach to the problem of inferring a consumer's utility model on the basis of observed evidence. Synthetic data are used to demonstrate its applicability to a variety of estimation problems. It is shown that the approach can compete favorably with Conjoint Analysis.

## Preferences and Bounded Rationality: Decisions in a Complex World

*Klaus Mainzer (Univ. Augsburg, D)*

Preferences and their representation in formal systems have a long tradition in logic and philosophy. Automated reasoning about preferences with ontologies and categories had been discussed in philosophy, before they were formalized in artificial intelligence and applied in databases.

But, in a complex world with nonlinear dynamics, there are no universal representations of preferences. Preferences are personalized, situated, context-dependent, and dynamic. We must act and decide with incomplete and fuzzy knowledge under the conditions of bounded rationality. Even in commercial affairs, motivations, emotions, and embodied interactions play an important role in our decision making.

Thus, cognitive science comes in. The theory of preferences and decisions must be supported and supplemented by cognitive studies, in order to develop human-oriented information systems.

Interdisciplinary collaboration is a challenge in a complex information world.

Literature: J. Chomicki, Preference Formulas in Relational Queries, in: ACM Transactions on Database Systems, vol.28, No. 4, 2003, 1-39; P.

C. Fishburn, Utility Theory for Decision Making, John Wiley & Sons: New York 1970; W. Kiessling, Foundations of Preferences in Database Systems, in: Proceedins of the 28th VLDB Conference, Hong Kong, China, 2002; K. Mainzer, Thinking in Complexity. The Computational Dynamics of Matter, Mind, and Mankind, Springer: New York 4th edition 2004.

## Preferences in Declarative Policy Description and Enforcement in Network Context

*Alessandra Mileo (Università di Milano, I)*

In my talk I will present my work on adding preferences to the Policy Description Language (PDL).

PDL is a simple declarative high-level specification language for policies and it has been defined by Chomicki, Lobo and Naqvi in the context of network management, where a policy is a description of how events received over a network (e.g. queries to data, connection requests, etc.) are served by some given network terminal, often identified as "data server". PDL also allow the specification of "monitors": description of sets of actions that cannot be executed simultaneously to prevent illegal, hazardous or physically impossible situation.

In my PhD work I am focussing on the possibility of expressing preferences on how a monitor should filter the output of a policy to maintain consistency. What we propose is a suitably extended version of PDL called Policy Description Language with Preferences (PPDL). The idea is that of recostructing Brewka's ordered disjunction connective [Brewka et al., 2002] into PDL and translating policies into Logic Programming with Ordered Disjunction (LPOD). LPOD programs can be executed by an extension of the Smodels solver (called Psmodels) implemented at Helsiky University of Technology. The straightforward embedding of PPDL into LPOD, however, raises some semantical problem. Since answer sets of LPOD are not necessarily minimal, we have to discuss the compromise between minimality of the solution and degree of user's satisfaction. So far we have experimented PPDL applying it to several application contexts, namely Network Management, Authorization Workflows and Preferential Connection to Web Services.

The result seem encouraging and suggests that PPDL can become a useful policy language.

## Axiomatic Approach to Concordance Relations in Conjoint Measurement Perspective

*Marc Pirlot (Faculté Polytechnique - Mons, B)*

The notion of concordance is central to many multiple criteria techniques relying on ordinal information, e.g. outranking methods. It leads to compare alternatives by pairs on the basis of a comparison of coalitions of attributes in terms of "importance". This paper proposes a characterization of the binary relations that can be obtained using such comparisons, within a general framework for conjoint measurement that allows for intransitive preferences. We show that such relations are mainly characterized by the very rough differentiation of preference differences that they induce on each attribute.

*Joint work of:* Bouysou, Denis; Pirlot, Marc

## User-Involved Preference Elicitation for Online Product Catalogs

*Pearl Pu (EPFL - Lausanne, CH)*

A crucial element in consumer electronic commerce is a catalog tool that not only finds the product for the user according to his preferences, but also convinces him that he has made the best choice. To do that, it is important to show him ample choices while keeping his interaction effort below an acceptable limit. Among the various interaction models used in operational e-commerce sites, ranked lists are by far the most popular tool for product navigation and selection. However, as the number of product features and the complexity of user's criteria increase, a ranked list's efficiency becomes less satisfactory. As an alternative, research groups from the intelligent user interface community have developed various example-based search tools, including SmartClient from our laboratory. These tools not only perform preference-based search, but also support tradeoff analysis. However, despite the academic interest, example-based search paradigms have not been widely adopted in practice.

We have examined the performance of such tools on a variety of tasks involving selection and tradeoff. The studies clearly show that example-based search is comparable to ranked lists on simple tasks, but significantly reduces the error rate and search time when complex tradeoffs are involved. This shows that such tools are likely to be useful particularly for extending the scope of consumer e-commerce to more complex products.

*Keywords:* User-involved preference elicitation, example critiquing interfaces, electronic catalogs, tradeoff analysis, e-commerce

## Voting Theory for Preference Aggregation

*Francesca Rossi (Universitá di Padova, I)*

We consider decision-making scenarios where multiple agents express their preferences as partial orders over the outcomes. The system has to aggregate such preferences and build a resulting partial order over the outcomes. We consider the specific scenario where agents use CP nets to express their preferences, and we propose an extension of CP nets (partial CP nets) where indifference is allowed. We then define mCP nets, which are sets of partial CP nets, and we propose five different semantics for mCP nets, all based on voting theory: Pareto, majority, max, rank, and lexicographic. We study the properties of such semantics and we relate their orderings over the outcomes. We then study them from the point of view of fairness, a property which is typically studied in the context of social choice theory. We then generalize the study of fairness to consider any multi-agent scenario where agents use partial orders and the result is a partial order, and we prove an impossibility result which extends Arrow's theorem: it is impossible to be fair if agents use partial orders with unique top and bottom, and the result is a partial order with unique top or unique bottom.

*Keywords:* Preference aggregation, voting theory, social choice, Arrow's impossibility theorem, fairness

*Joint work of:* Rossi, Francesca; Venable, Kristen Brent; Walsh, Toby

## Soft Constraints

*Francesca Rossi (Universitá di Padova, I)*

Soft constraints are a generalization of classical "hard" constraints that allow for several degrees of satisfaction and violation. They are useful for problems with preferences and for over-constrained problems. Several frameworks exist for modelling soft constraints. One of the most general ones is based on semirings. Others are: valued constraints, fuzzy constraints, probabilistic constraints, weighted CSPs, etc.

I will describe many different frameworks and relate their expressive power. I will then describe the main techniques that are used to solve soft constraints: branch and bound, soft constraint propagation, cut method, and variable elimination.

*Keywords:* Constraint programming, constraint propagation, preferences, soft constraints

## Preferences on Intervals: a general framework

*Alexis Tsoukias (Université Paris-Dauphine, F)*

I present a general framework for the comparison of alternatives to which (possibly) an interval of values is associated. Some representation theorems for the existence of the intervals are discussed as well the possibility ot explicitly take into account situations of hesitation.

Some appropriate logical formalisms are discussed for such a purpose.

*Keywords:* Preferences, Interval Orders, Hesitation, Logical formulation

*Joint work of:* Tsoukias, Alexis; Öztürk, Meltem

*Full Paper:* http://drops.dagstuhl.de/opus/volltexte/2006/401

## Preference Modelling

*Alexis Tsoukias (Université Paris-Dauphine, F)*

This paper provides the reader with a presentation of preference modelling fundamental notions as well as some recent results in this field. Preference modelling is an inevitable step in a variety of fields: economy, sociology, psychology, mathematical programming, even medicine, archaeology, and obviously decision analysis. Our notation and some basic definitions, such as those of binary relation, properties and ordered sets, are presented at the beginning of the paper. We start by discussing different reasons for constructing a model or preference. We then go through a number of issues that influence the construction of preference models. Different formalisations besides classical logic such as fuzzy sets and non-classical logics become necessary. We then present different types of preference structures reflecting the behavior of a decision-maker: classical, extended and valued ones. It is relevant to have a numerical representation of preferences: functional representations, value functions. The concepts of thresholds and minimal representation are also introduced in this section. In section 7, we briefly explore the concept of deontic logic (logic of preference) and other formalisms associated with "compact representation of preferences" introduced for special purpoes. We end the paper with some concluding remarks.

*Keywords:* Preferences, Interval Orders, Hesitation, Logical formulation

*Joint work of:* Tsoukias, Alexis; Öztürk, Meltem; Philippe, Vincke

*Full Paper:* http://drops.dagstuhl.de/opus/volltexte/2006/450

## Combining Preferences and Constraints

*Toby Walsh (Univ. of New South Wales - Sydney, AU)*

Joint work with Steve Prestwich, Francesca Rossi, and Brent Venable.

I will discuss how we can reason about preferences in the presence of hard and soft constraints. For example, in configuarion problems we often have preferences (e.g. what the user would like), hard constraints (e.g. what components are compatible) and soft constraints (e.g. what we have in stock). I will show how preferences can be compiled down into hard constraints so we can reason just about hard constraints.

Note: I must leave Thurs lunch so I need to present this seminar on or before this time. Thanks.

*Keywords:* Preferences, constraints

## Constrained CP-nets

*Toby Walsh (Univ. of New South Wales - Sydney, AU)*

Preferences and constraints occur together in many problems. For instance, in product configuration, there are physical constraints on what can be built (e.g. a convertible car cannot have a roof rack), as well as the user's preferences (if the car is a convertible, then I prefer a boot rack to no boot rack). Preferences have been widely studied in decision-theoretic AI. However, much less is known about reasoning simultaneously with preferences and constraints, as in the product configuration example above. Constrained preference optimization is a challenging problem as often the most preferred outcome is not feasible, and not all feasible outcomes are equally preferred. I discuss a framework, constrained CP-nets, for doing such reasoning.

*Keywords:* Preferences, CP-networks, constraints

*Full Paper:* http://www.cse.unsw.edu.au/ tw/prvwaaai05.pdf

## A Logic of Conditional Preferences

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This talk was based on two conferences papers: Extending CP-Nets with Stronger Conditional Preference Statements (AAAI 2004), and Consistency and Constrained Optimisation for Conditional Preferences (ECAI 2004), available from the author's webpage: http://www.4c.ucc.ie/web/people.jsp?id=73

In this work, a logic of conditional preferences is defined, with a language which allows the compact representation of certain kinds of conditional preference statements, a semantics and a proof theory. CP-nets and TCP-nets can be

expressed in this language, as can lexicographic orders. The semantics and proof theory generalise those of CP-nets. Despite being substantially more expressive, the formalism maintains important properties of CP-nets. For the fully acyclic case, there are simple sufficient conditions for consistency, and, under these conditions, optimal outcomes can be efficiently generated. It is also then easy to find a total order on outcomes which extends the conditional preference order, and an approach to constrained optimisation can be used which generalises a natural approach for CP-nets. These methods generalise to some extent for conditional preference theories which are not fully acyclic.

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